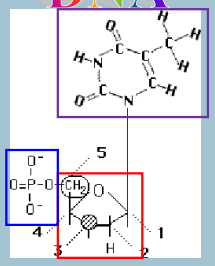
GENETIC REGULATION OF PROTEINS

NUCLEIC ACIDS

DNA

- *Double helix*
- *NOT made of amino acids*

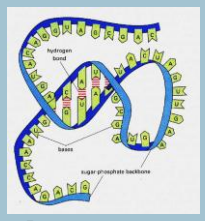


Deoxyribose + phosphate + base = nucleotide

NUCLEIC ACIDS

RNA

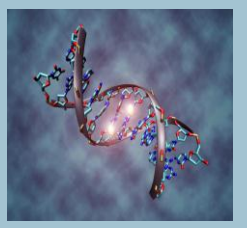
- *Single helix*
- *Uracil*
- *tRNA, mRNA, rRNA*



Ribose + phosphate + base = nucleotide

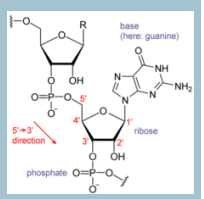
NUCLEIC ACIDS STORE AND TRANSMIT HEREDITARY INFORMATION

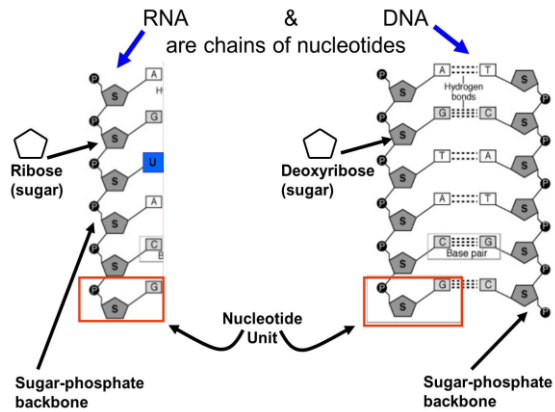
- *Two types of nucleic acids:*
  - ***ribonucleic acid (RNA)***
  - ***deoxyribonucleic acid (DNA).***
- *DNA provides direction for its own replication.*
- *DNA also directs RNA synthesis and, through RNA, controls protein synthesis.*
- *Organisms inherit DNA from their parents.*



A NUCLEIC ACID STRAND IS A POLYMER OF NUCLEOTIDES

- *Nucleic acids are made from repeating* ***nucleotide*** *units.*
- *Nucleotide components:*
  - *a nitrogen base*
  - *a pentose sugar (deoxyribose or ribose)*
  - *a phosphate group*

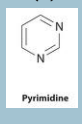




NITROGEN BASES: PYRIMIDINES AND PURINES

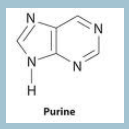
Pyrimidines

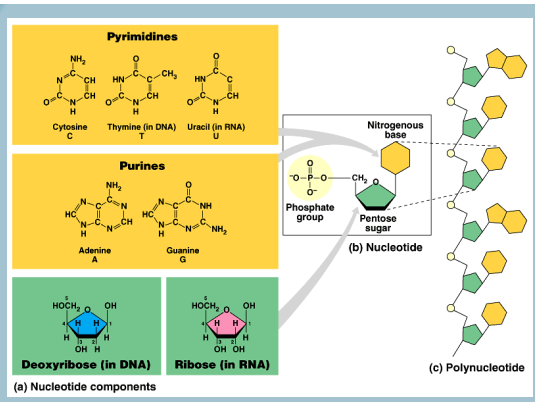
- *Single ring*
- *Differ in attachments to the ring*
- *Cytosine (**C**), thymine (**T**), and uracil (**U**)*



Purines

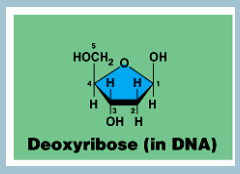
- *Double ring*
- *Differ in attachments to the ring*
- *Adenine (**A**) and guanine (**G**).*

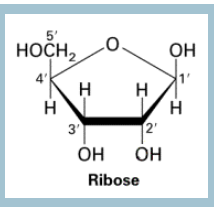




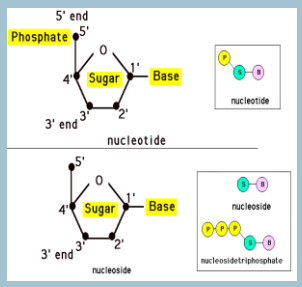
"THE PENTOSE SUGAR"

- *In DNA this is DEOXYRIBOSE*
- *CANNOT simply call it "sugar" on the AICE exam!*



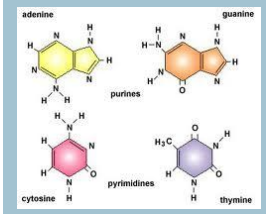


PUTTING IT TOGETHER…

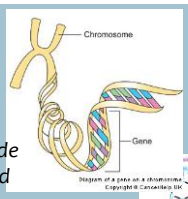


- *Nitrogen base + deoxyribose = nucleoside*
  - *Nucleoside monophosphate = nucleoside + phosphate (nucleotide)*
  - *Two phosphates would be a nucleoside diphosphate*

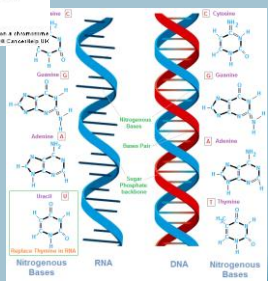
WHAT'S IMPORTANT ABOUT NUCLEOTIDES?



- *Different combinations are endless*
- *Give us all of our possible **genes***
  - *hundreds to thousands of nucleotides long*
  - *"code" for different genetic traits*
- *Many genes make up a **genome***
  - *All of the genes in a given organism*
  - *Complete genetic code*

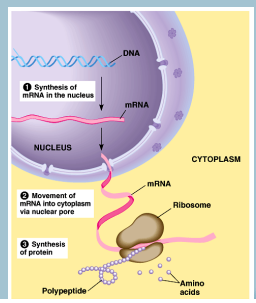


- *The amino acid sequence of a polypeptide is programmed by a **gene**.*
- *A gene consists of regions of DNA, a polymer of **nucleic acids**.*
- *DNA (and their genes) is passed by the mechanisms of inheritance—more to come later!!*

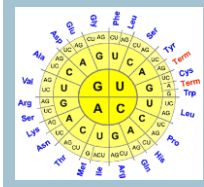


The Central Dogma: The flow of genetic information is from DNA -> RNA -> protein

- Protein synthesis occurs in ribosomes
- In eukaryotes, DNA is located in the nucleus, but most ribosomes are in the cytoplasm with mRNA as an intermediary
  - So how will we get this genetic code to where it needs to be?



WHAT DO GENES DO?

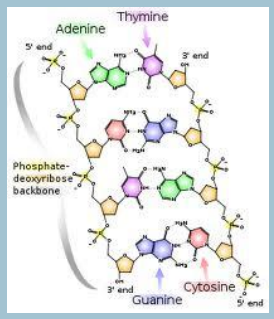


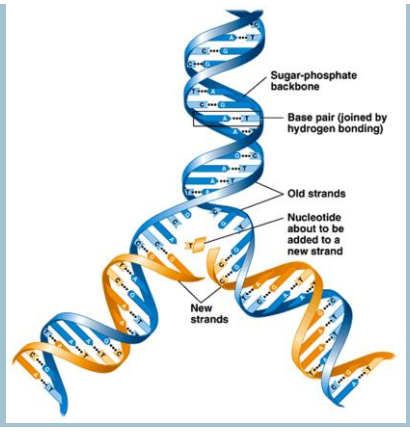
- *Each gene in a strand of DNA is the code for a single protein*
- *Recall that proteins are what DO everything in your body*
- *The order of nucleotides in genes, organized in "the triplet code," is what determines the order of amino acids in the protein*
- *Three nucleotides determine one amino acid*

	U	C	A	G	
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

DNA STRUCTURE

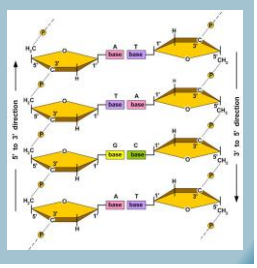
- *Double helix*
- *Nucleotides in the middle*
- *Nucleotides bond to deoxyribose-phosphate "backbone"*

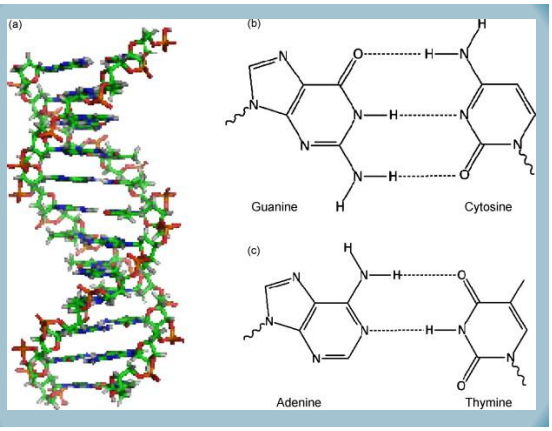




BASE PAIRING RULES:

- ***In DNA, adenine (A) always pairs with thymine (T) and guanine (G) with cytosine (C).***
- ***With these base-pairing rules, if we know the sequence of bases on one strand, we know the sequence on the opposite strand.***
- ***The two strands are complementary.***
- ***"Go Climb A Tree"***



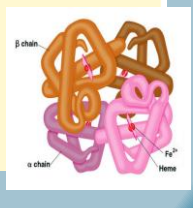


WE CAN USE DNA AND PROTEINS AS TAPE MEASURES OF EVOLUTION

- *DNA molecules are passed from parents to offspring, so…*
  - *siblings have greater similarity than unrelated individuals of the same species.*
  - *This argument can help develop a molecular genealogy between species.*
- *Two species that appear to be closely-related based on fossil and molecular evidence should also be more similar in DNA and protein sequences.*
- *The sequence of amino acids in hemoglobin molecules differ by only one amino acid between humans and gorilla → BEAUTIFUL!!*

Table 5.2 Polypeptide Sequence as Evidence for Evolutionary Relationships

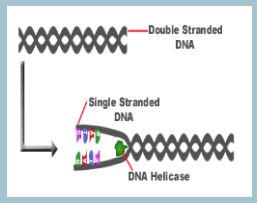
Species	Number of Amino Acid Differences in the β Chain of Hemoglobin, Compared to Human Hemoglobin (Total Chain Length = 146 Amino Acids)
Human	0
Gorilla	1
Gibbon	2
Rhesus monkey	8
Mouse	27
Frog	67



DNA REPLICATION

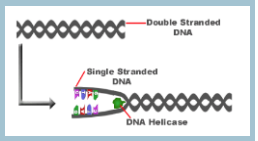
DNA UNWINDING

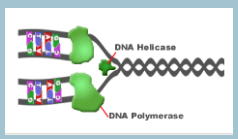
- *First step in replication*
- *Double helix unwound by* ***topoisomerase***
- *Double helix is "unzipped" by the enzyme* ***DNA helicase***
- *Enzyme breaks apart the hydrogen bonds between each set of base pairs*
  - *A-T have 2 hydrogen bonds compared to 3 hydrogen bonds in G-C*



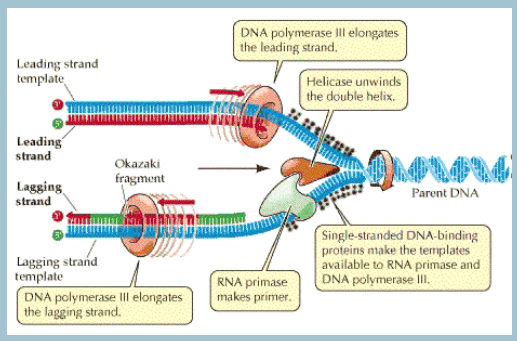
BEGINNING TO BUILD THE NEW DNA STRANDS

- *As the DNA molecule is "unzipped," new complementary strands are built up along each parent strand*
- *Creates a "replication fork"*
- *This process is accomplished by the enzyme* ***DNA polymerase***
- *Attaches new nucleotides to the free 3' end of the deoxyribose sugar*

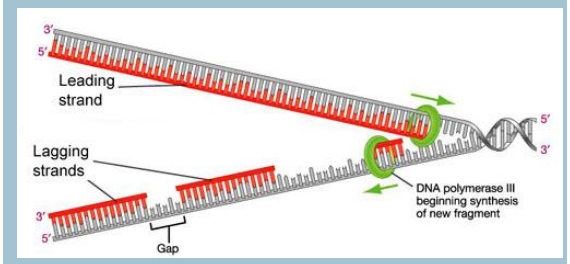




3' TO 5' PRIME CHAIN BUILDING:

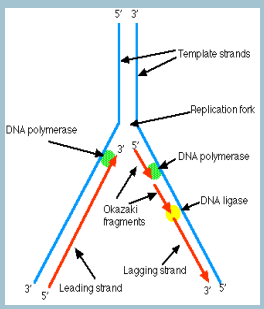


- *Continuous 3' to 5' building is what creates the LEADING STRAND*



LEADING AND LAGGING STRANDS

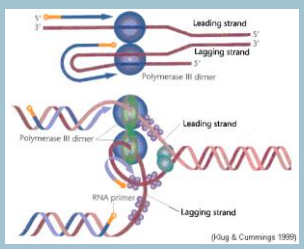
- *While DNA polymerase builds DNA up in the leading strand direction…*
- *A slightly different type of DNA polymerase begins building in the 3' to 5' direction*
- *Creates discontinuous sections of DNA called **Okazaki fragments**, marked off by **RNA primase***
- *This is because DNA can only build from a 3' to 5' direction (can only attach to the 3' end)*
- *Referred to as the LAGGING STRAND*



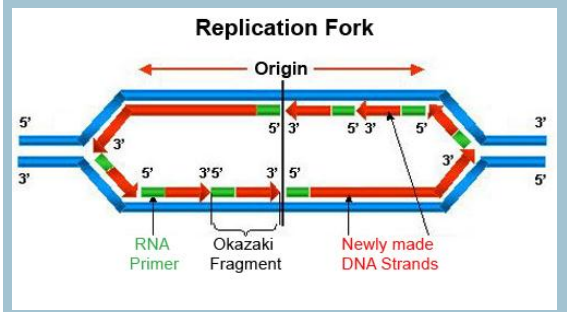
LEADING AND LAGGING STRANDS

- http://www.youtube.com/watch?v=-mtLXpgjHLo&feature=related

MEMORY TRICK

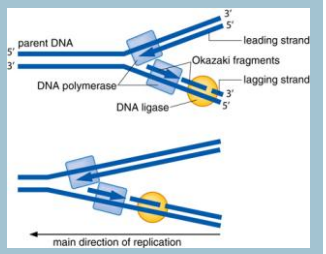


- *Leading strand: LEADS the way, moves continually in the same direction*
- *Lagging strand: LAGS behind because it is building DNA in small sections*

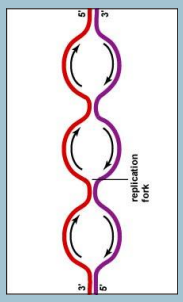


DNA CLEAN-UP

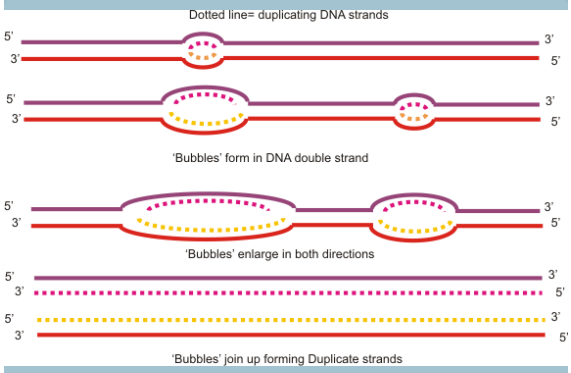
- ***DNA ligase*** *comes in and adds in any additional phosphates needed to complete the DNA chain*



SPEED OF REPLICATION



- *Average human chromosome is 150 x 10^6 nucleotides long.*
- *Nucleotides are copied at about 50 BP a second*
- *Replicating a single DNA molecule would take a month, except…*
- *Multiple points of origin of replication which leads to replication bubbles*



- *Crash Course, DNA and Replication (this is great and you're not going to make fun of it): http://www.youtube.com/watch?v=8kK2zwjRV0M*
- *Simulation: http://www.johnkyrk.com/DNAreplication.html*